



WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: 2005OH26B

Title: Use of Persulfate and Peroxymonosulfate Oxidants for the Destruction of Groundwater Contaminants

Project Type: Research

Focus Categories: Treatment, Groundwater, Methods

Keywords: Advanced Oxidation Technologies, sulfate radicals, hydroxyl radicals, iron, peroxymonosulfate, persulfate, trichloroethylene, atrazine, MTBE, chemical oxidation, nanoparticulate zero valence iron

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Non-Federal Matching Funds: \$30,008

Congressional District: 01

Principal Investigator:

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Abstract

USE OF PERSULFATE AND PEROXYMONOSULFATE OXIDANTS FOR THE DESTRUCTION OF GROUNDWATER CONTAMINANTS

Abstract

This proposal deals with novel advanced chemical oxidation technologies for groundwater treatment. This advanced oxidation technologies (AOTs) comprise iron/peroxymonosulfate (PMS) ($\text{Fe}^{2+}/\text{PMS}$ or $\text{Fe}^{3+}/\text{PMS}$) or iron/persulfate (Fe^{2+}/PS or Fe^{3+}/PS). These technologies are based on the generation of hydroxyl and sulfate radicals, which are among the most powerful oxidizing species found in nature. These technologies can be viewed as novel modifications of the Fenton Reagent ($\text{Fe}^{2+}/\text{H}_2\text{O}_2$) (FR), an already established AOT process, which is based on the generation of hydroxyl radicals. However, in the proposed technologies, the kinetics of the reaction of iron with PMS or PS are slower compared to that of FR and allow for the action of such chemicals for much longer duration. In such a case, the chemical oxidation system can eliminate

contamination occurring even after the application of the oxidants. In addition, the effectiveness of nanoparticle zero valence iron combined with PMS or PS will also be investigated.

Motivated by promising preliminary data, this proposal aims at further studying the iron/PMS and iron/PS reagents as new chemical oxidation technologies for the treatment of organic contaminants in groundwater. The proposed research plan includes two phases. In the first phase, we propose to further investigate the mechanisms of iron/PMS and iron/PS chemical oxidation at a fundamental level and provide more comprehensive understanding of transition metal chemical oxidation based on PMS and PS oxidants. In the second phase we will determine the efficiency of iron/PMS and iron/PS systems for the treatment of selected groundwater contaminants with significantly different chemical structure and physicochemical properties. These groundwater contaminants include trichloroethylene, the pesticide atrazine, and gasoline additive methyl tert-butyl ether.

The proposed study has a high intellectual merit since it will introduce, for the first time, a new and promising AOT (iron/PMS) for groundwater treatment. This will give new direction on the development of modern AOTs that can act for much longer times. Second, we propose to perform a fundamental investigation of the forward (i.e., $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$) and reverse (i.e., $\text{Fe}^{3+} \rightarrow \text{Fe}^{2+}$ via peroxymonosulfate or persulfate) electron transfer reactions to gain further insights of the potential of these transition metal-based catalytic chemical systems. This will enhance the scientific knowledge of the current chemical oxidation technologies. Third, we seek to understand the fundamental mechanisms of sulfate radical attack on structurally different organic contaminants in water and to unveil the detailed chemical oxidation pathways. This will bring new information for the similarities and differences between sulfate and hydroxyl radicals as oxidizing species in the destruction of organic pollutants in water and will provide a rationale for the reactivity of certain chemical bonds under sulfate radical attack.

The proposal has also the potential for a great broad impact since it will enhance our capabilities to treat contaminated groundwater as well as other types of contaminated water. The study will serve as an alternative remedial technology to solve problems where other established technologies (i.e., Fenton Reagent) face field limitations. The project will involve training of one graduate student who will participate in the project. The requested funding is mainly to support 50% of the student's stipend.